PSY.

SOLID STATE

VARIABLE FILTER

MODEL 3750(R) SERIAL NO. 2364

OPERATING AND MAINTENANCE MANUAL

KH

KROHN-HITE CORPORATION
Avon Industrial Park/Bodwell St., Avon Massachusetts 02322 U.S.A.

Service and Warranty

KROHN-HITE Instruments are designed and manufactured in accordance with sound engineering practices and should give long trouble-free service under normal operating conditions. If your Instrument fails to provide satisfactory service and you are unable to locate the source of trouble, contact our Representative if there is one in your area or write to our Service Department giving all the information available concerning the failure.

Do not return the instrument without our written authorization for, in most cases, we will be able to supply you with the information necessary to repair the instrument and thus avoid the transportation problems and costs. When it becomes necessary to return the instrument to our Factory, kindly pack it carefully and ship it to us via Railway Express, prepaid.

All KROHN-HITE products are warranted against defective materials and workmanship. This warranty applies for a period of one year from the date of delivery to the original purchaser. Any instrument that is found within the one year period not to meet these standards, will be repaired or replaced. All instruments returned for repair and/or recalibration are insured by Krohn-Hite while on the premises. This warranty does not apply to electron tubes, fuses, or batteries. No other warranty is expressed or implied.

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580 Massachusetts Ave., Cambridge, Mass. 02139 U.S.A.

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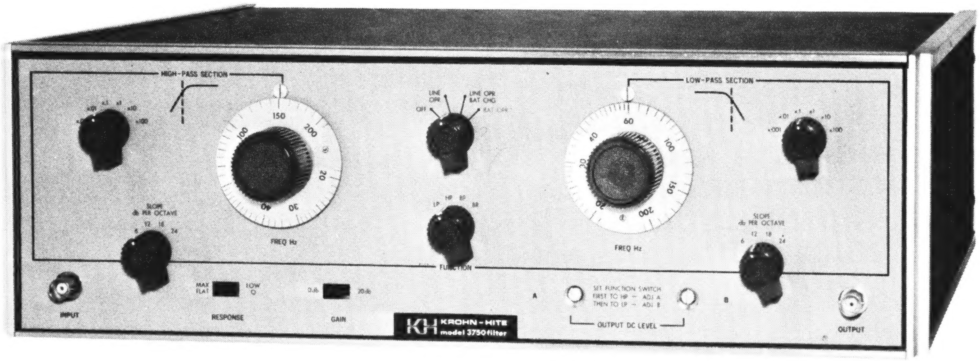
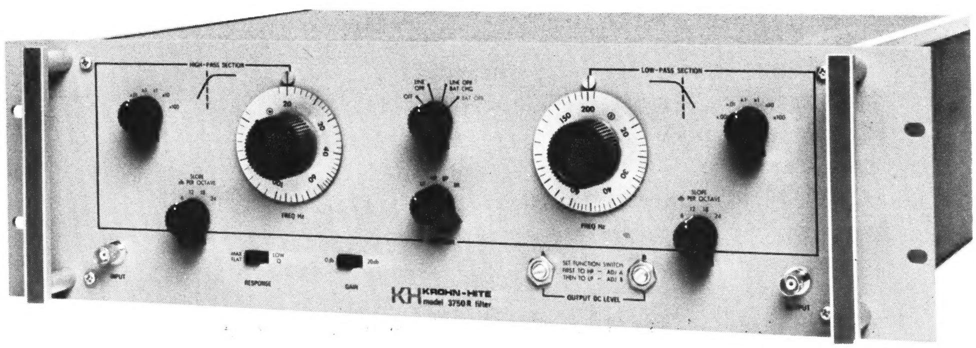


Model 3750



Model 3750R

Figure 1. Model 3750(R)

SECTION 1
GENERAL DESCRIPTION

1.1 INTRODUCTION

The Model 3750(R) is a variable electronic filter covering the frequency range from 0.02 Hz to 20 kHz, and operable in any one of four functional modes; high-pass, low-pass, band-pass or band-reject. The mode of operation is selected by means of a front panel FUNCTION switch. The pass-band gain is unity (0db) or 10 (20db), as selected by a front panel GAIN switch, with attenuation slopes of 6, 12, 18 or 24 db per octave, as selected by 2 front panel SLOPE switches.

The cut-off frequencies of both the high-pass and the low-pass sections are independently adjustable from 0.02 Hz to 20 kHz. Operation in the band-pass or band-reject modes permits passage or rejection of any band of frequencies between these limits. In the low-pass and band-reject modes, the filter is direct coupled, passing all frequencies from DC to the selected cut-off frequency of the low-pass section. In the high-pass and band-reject modes, the upper 3 db point is at approximately 1 megacycle for 0 db gain, and approximately 200 kc for 20 db gain.

Battery operation capability is included in all instruments and batteries (four nickel cadmium rechargeables) may be added at any time.

1.2 GENERAL SPECIFICATIONS

Frequency Ranges

Continuous coverage from 0.02 Hz to 20 kHz for both cut-off frequencies, independently. Frequency range is covered by separately calibrated dials and six-decade band switches. Center frequency and width of pass-band in band-pass mode are continuously adjustable over the entire frequency range.

BAND	MULTIPLIER	FREQUENCY (Hz)
1	.001	.02 - 0.2
2	.01	0.2 - 2.0
3	.1	2.0 - 20
4	1.0	20 - 200
5	10.0	200 - 2,000
6	100.0	2,000 - 20,000

Accuracy of Cut-Off Frequency Calibration

± 5% in the 24 db slope position with RESPONSE switch in the MAX FLAT (Butterworth) position; less accurate in LOW Q and other slope positions (±10% band 6 and below .05 Hz). Relative to mid-band level, the filter output is down 3 db at cutoff in the MAX FLAT position. In the LOW Q position, the output is down approximately 11 db with 24 db slope; 9 db with 18, 7 db with 12 and 3 db with 6 db slope.

Bandwidth

Band-Pass Mode: Continuously variable within the cutoff frequency limits of 0.02 Hz and 20 kHz. For minimum bandwidth the high-pass and low-pass cutoff frequencies are set equal. This produces an insertion loss of 6 db, with the -3 db points at 0.8 and 1.25 times the midband frequency.

Band-Reject Mode: Continuously variable within the cutoff frequency limits of 0.02 Hz and 20 kHz or sharp null at any frequency between 0.04 Hz and 10 kHz. The low-pass band extends to dc. The high-pass band has its upper 3 db point at approximately 1 megahertz for 0 db gain and approximately 200 kHz for 20 dB gain. The null is sharper than that of a balanced parallel T filter, and is obtained by setting the high-pass cutoff to approximately twice the desired null frequency, and the low-pass cutoff to approximately half the desired null frequency.

High-Pass Mode: Continuously variable, with cutoff frequency adjustable from 0.02 Hz to 20 kHz. The upper 3 db point is at approximately 1 megahertz for 0 db gain and approximately 200 kHz for 20 db gain.

Low-Pass Mode: Continuously variable, with cutoff frequency adjustable from 0.02 Hz to 20 kHz. The pass band extends to dc at the low end.

Attenuation Slope

Each cutoff independently adjustable to 6, 12, 18, or 24 db per octave.

Maximum Attenuation

Greater than 80 db for 24 db per octave position.

Response Characteristics

Choice of Butterworth (maximum flat response) for frequency domain operation and Low Q (damped response) for transient-free time domain operation, selected by means of a front panel switch.

Pass-Band Gain (selected by front panel control)

0 ±1 db or 20 ±1 db.

Input Characteristics

Maximum Voltage: ±15 volts peak in the 0 db gain position. ±1.5 volts peak in the 20 db gain position to 50 kHz.

Maximum DC Component: 100 volts in BAND-PASS and HIGH-PASS modes. In LOW-PASS and BAND-REJECT modes, the combined ac and dc voltage should not exceed 15 volts peak for 0 db gain or 1.5 volts peak for 20 db gain.

Impedance: 10 megohms in parallel with 200 pf.

Output Characteristics

MAX VOLTAGE: 15 volts peak.

MAX CURRENT: 3 ma. peak.

INTERNAL IMPEDANCE: approximately 50 ohms.

Hum and Noise

500 μv rms in the 0 db gain position, 500μv rms (700 μvrms in the band reject mode) in the 20 db gain position, for a detector bandwidth of 100 kHz.

Output DC Level Stability

±1 millivolt per hour, ±5 millivolts per degree C.

Operating Temperature Range

0°C to 45° C

Power Requirements

105-125 or 210-250 volts, single phase, 50-400 Hz. 10 watts. (Hum is increased a factor of two for 400 Hz operation). Internal Battery (4 required). Battery will operate 8 hours without recharging.

SECTION 2
OPERATION

2.1 INTRODUCTION

The filter is thoroughly checked and carefully adjusted before shipment to insure that it meets all stated specifications. The filter is shipped complete, and after unpacking, is ready to be used.

Unpack the filter carefully and inspect it for damage that may have occurred during shipment. Check the case for damage and check for loose sub-assemblies and parts. Check all controls and adjustments for freedom of operation. The recommended operating procedure is given below.

2.2 POWER REQUIREMENTS OF FUSES

The filter can be wired for operation from an AC power source of either 105-125 volts 50-400 Hz, or 210-250 volts, 50-400 Hz. When connected for 105-125 volt operation, the primary sections of the power transformer are connected in parallel by connecting the red wire with the green wire, and the white wire with the blue wire. When connected for 105-125 volt operation, the filter uses a 0.3 ampere slow-blow fuse. When wired for 210-250 volt operation, the primary sections are connected in parallel – the green wire is connected to the white wire, and a 0.15-ampere fuse is used. The terminals for connecting the wires are on the power supply board, toward the transformer. When batteries are used, the filter may be operated for 8 hours without recharging.

2.3 OPERATING PRECAUTIONS

Observe the following limitations on the filter input signal:

MAXIMUM INPUT AMPLITUDE: ±15 volts peak with GAIN switch in 0 db position, ±1.5 volts peak with GAIN switch in 20 db position. Above 50 kHz the allowable input signal decreases at the rate of 6 db per octave, reaching approximately ±.7 volt peak at 1 megacycle with 20 db gain.

MAXIMUM DC COMPONENT: ±100 volts, in band-pass and high-pass modes. In low-pass and band-reject modes, the combined peak ac input voltage and dc input voltage should not exceed 15 volts peak for 0 db gain or 1.5 volts peak for 20 db gain.

The following limitations apply to the Filter output signal:

MAXIMUM VOLTAGE:	±15 volts peak.
MAXIMUM CURRENT:	3 ma. peak.
INTERNAL IMPEDANCE:	Approximately 50 ohms.

2.4 OPERATION (Figure 2-1)

2.4.1 Make appropriate power connections as described in Paragraph 2.2.

2.4.2 Make appropriate connections to the INPUT and OUTPUT terminals of the filter. A chassis ground terminal is provided on the rear panel for connection to system ground. If the filter is to be used where ground currents may be a problem, it may be advantageous to switch the GROUND switch to the FLTG position. However, because of the possibility of noise being picked up by capacity coupling to high impedance circuits, signal ground is usually connected to system ground.

2.4.3 Select correct GAIN setting for the signal level in use. Note that while the maximum input signal in the 20 db position is ±1.5 volts peak and the maximum input in 0 db is ±15 volts peak, the maximum output signal in both cases is ±15 volts peak. Observe the precautions of Paragraph 2.3 with regard to maximum input signal amplitude within the tuning range and also the maximum amplitude-versus-frequency limitation for frequencies above the tuning range.

2.4.4 Turn the FUNCTION switch to the desired mode of operation.

2.4.5 Set both HIGH and LOW pass slope switches to desired attenuation.

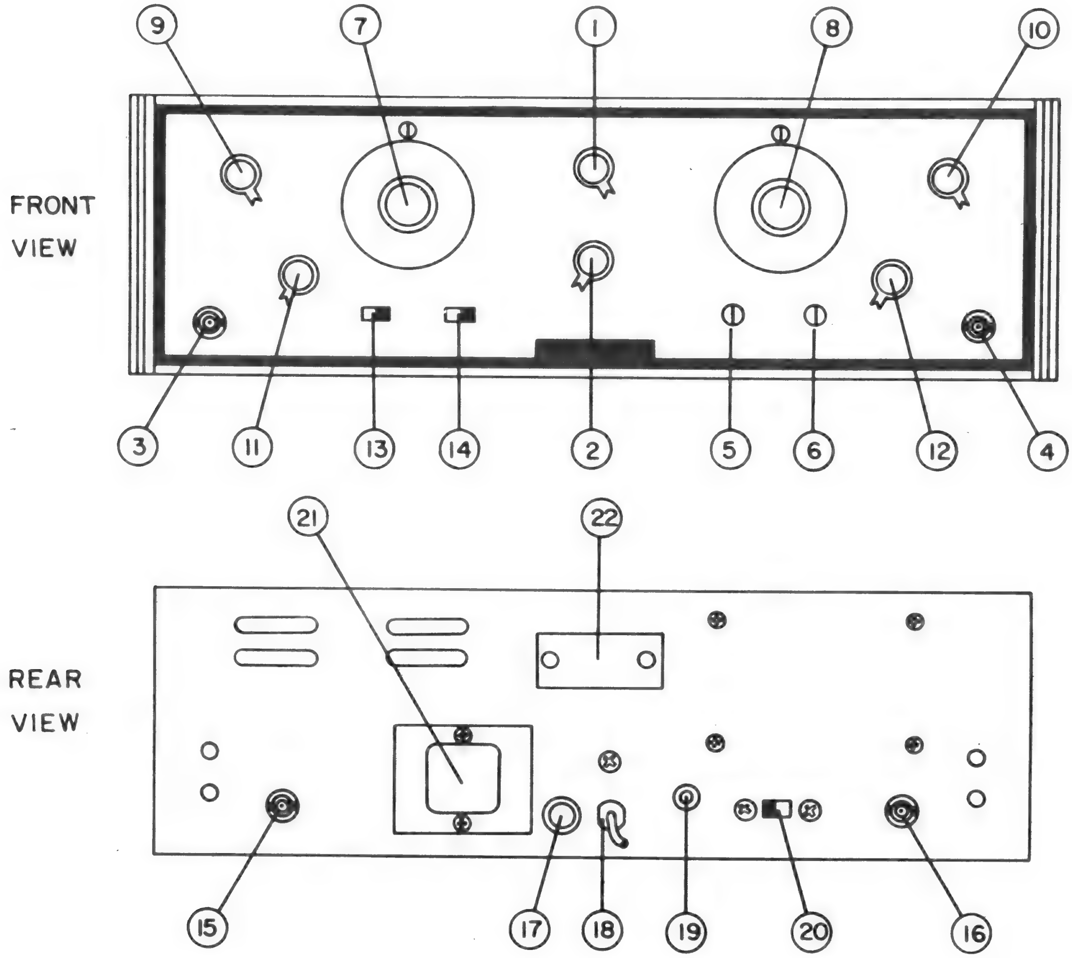
2.4.6 Set desired cutoff frequencies by means of the frequency selection dials and switches.

2.4.7 Set the POWER switch to the appropriate position.

2.5 SPECIAL FUNCTIONS

2.5.1 Pass Band Response

The flexibility of adjustment of bandwidth is illustrated in Figure 2-2; Low Pass, High Pass, and Band-pass operation in the MAXimally FLAT or Butterworth mode are illustrated by curves A, B, and C. Curve C shows the variation available in the slope selection feature, and the minimum bandwidth, obtained by setting the two cutoff frequencies equal. In this condition the insertion loss is 6 db, and the 3 db



(1) POWER SW. (OFF/ LINE/LINE BAT CHG/BAT OPR)
(2) FUNCTION SWITCH (HP, LP, BP, BR)
(3) INPUT CONNECTOR (BNC TYPE)
(4) OUTPUT CONNECTOR (BNC TYPE)
(5) OUTPUT DC LEVEL (HIGH PASS)
(6) OUTPUT DC LEVEL (LOW PASS)
(7) FREQUENCY DIAL (LOW CUTOFF)
(8) FREQUENCY DIAL (HIGH CUTOFF)
(9) MULTIPLIER SWITCH (HIGH PASS)
(10) MULTIPLIER SWITCH (LOW PASS)
(11) SLOPE SWITCH (HIGH PASS)
(12) SLOPE SWITCH (LOW PASS)
(13) RESPONSE SWITCH (MAX FLAT/LOW Q)
(14) GAIN SWITCH (0db , 20db)

(15) OUTPUT CONNECTOR (BNC TYPE)
(16) INPUT CONNECTION (BNC TYPE)
(17) FUSE (.3A SLO-BLO 117V/ .15A SLO-BLO 234V)
(18) LINE CORD
(19) CHASSIS GROUND CONNECTOR (BINDING POST)
(20) GROUND SWITCH (FLOATING/CHASSIS)
(21) POWER TRANSFORMER
(22) NAMEPLATE

Figure 2-1. Front and Rear Panels

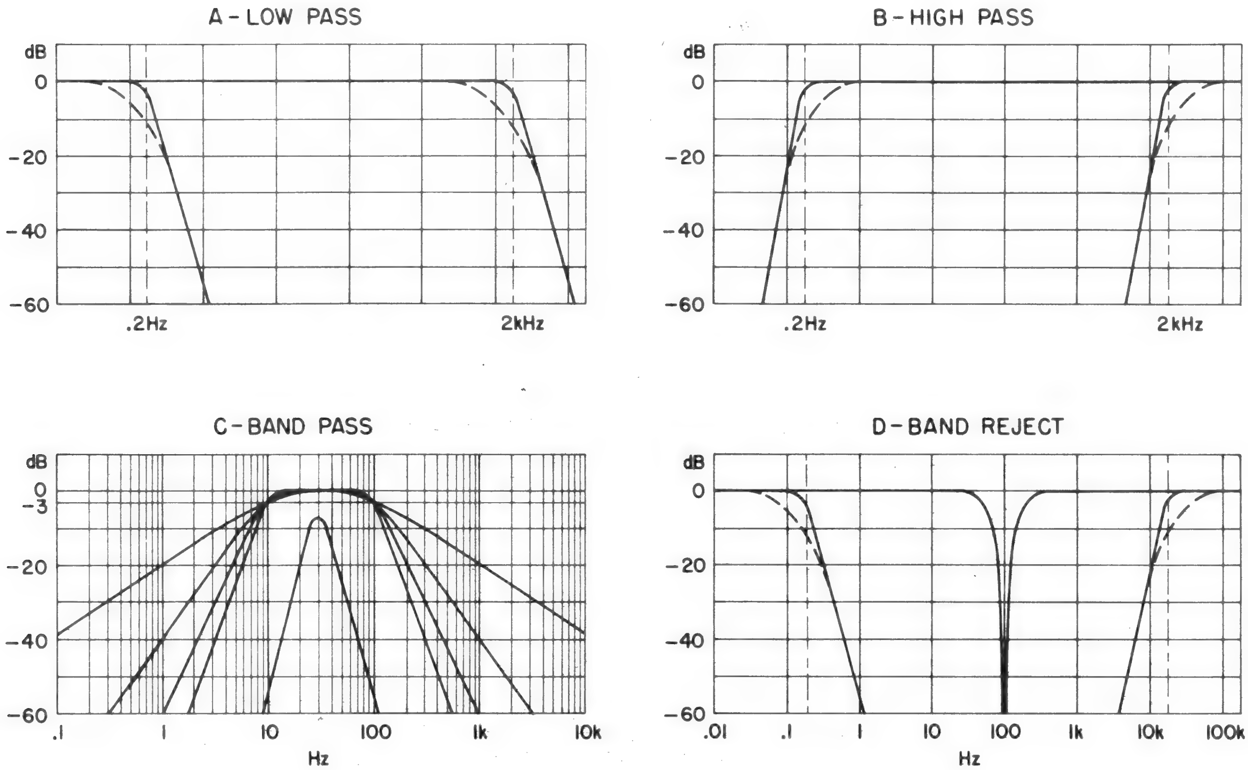


Figure 2-2. Pass Band Response: A-Low Pass, B-High Pass, C-Band Pass, D-Band Reject

cutoff frequencies occur at 0.8 and 1.25 times the mid-band frequency. The minimum pass-band for less than 1% insertion loss is obtained with the cutoffs set at 0.5 and 2 times the mid-band frequency.

The attenuation characteristics of the filter with -24 dB/octave attenuation are shown in Figure 2-2, curves A and B. With the response switch in the MAXimally FLAT or Butterworth mode, the gain, as shown by the solid curve, is virtually flat until the -3 dB cutoff frequency. At approximately two times the cutoff frequency the attenuation rate coincides with the 24 dB per octave straight line asymptote. In the LOW Q mode, optimum for transient-free filtering, the dotted line shows that the gain is down approximately 12 dB at cutoff and reaches 24 dB per octave attenuation rate at five times the cutoff frequency. Beyond this frequency the filter attenuation rate and maximum attenuation in both modes are identical.

Figure 2-2, curve D, shows the band reject characteristics of the filter. A sharp null can be obtained by setting the low-pass cutoff to half the desired rejection frequency, and the high-pass cutoff to twice the frequency, and adjusting the dials for minimum response.

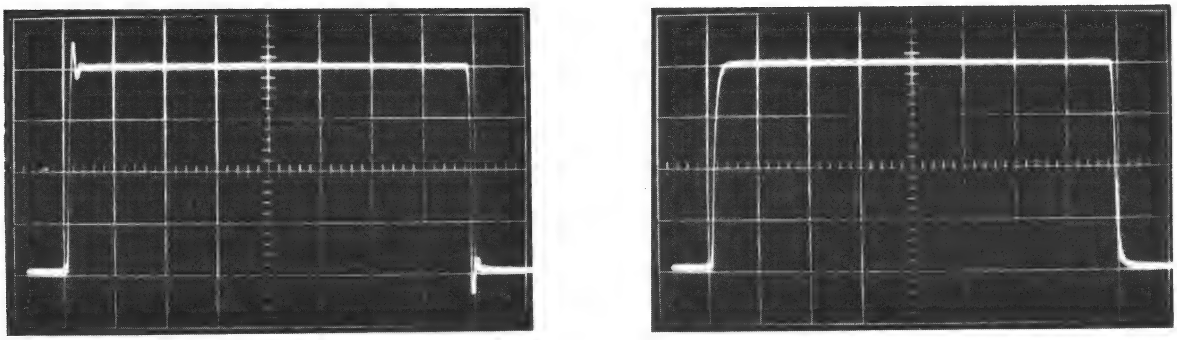


Figure 2-3. Square Wave Response Characteristics

2.5.2 Square Wave Response

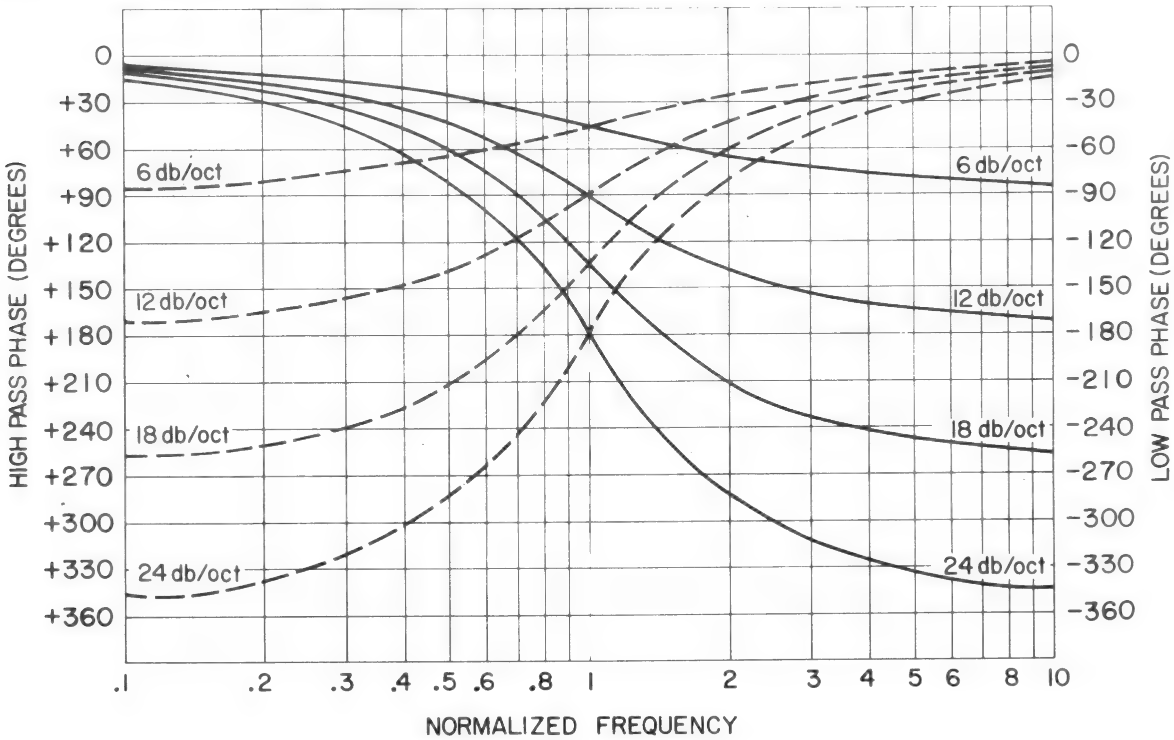
The frequency response characteristic of this Filter is a fourth order Butterworth function ideal for filtering in the frequency domain. For pulse or transient signal filtering, a response switch is provided to change the frequency response to Low Q, optimum for transient-free filtering. Figure 2-3 shows a comparison of the filter output response in these modes to a square wave input signal.

2.5.3 Phase Response

The phase shift through a band-pass filter at any frequency is the sum of the angles due to the high-pass and low-pass sections of the filter. Figure 2-4 gives the phase characteristics for both high- and low-pass sections, at the selected attenuation slopes. The ordinates are in degrees phase shift, negative for the low pass section and positive for the high pass section. The abcissa is the ratio of input frequency to cutoff (f/f_{LCO} or f/f_{HCO}.)

<u>Example:</u>

Determine the phase shift through the filter with the high pass (f_{LCO}) at 200 Hz, and the low pass (f_{HCO}) at 600 Hz, and an input frequency (f) of 300 Hz, at 18 dB/octave attenuation.



—— Low pass phase angle (right ordinate) = $\frac{f}{f_{HCO}}$

– – – High pass phase angle (left ordinate) = $\frac{f}{f_{LCO}}$

Figure 2-4. Phase Response

1) Phase shift due to low pass

$$\frac{f}{f_{HCO}} = \frac{300}{600} = 0.5$$

from figure 2-7, phase shift is -60°

2) Phase shift due to high pass

$$\frac{f}{f_{LCO}} = \frac{300}{200} = 1.5$$

from figure 2-7, phase shift is $+80^\circ$

3) Total phase shift = $-60^\circ + 80^\circ = +20^\circ$

Phase shift through a band-reject filter requires vector addition of the signal components passed by the two filter sections, and is difficult to calculate. In actual cases it is much more easily determined by measurement of the relative phase angle of the resultant output signal.

2.6 INSTALLATION OF BATTERY KIT

2.6.1 Material Required

Item	Quantity	Part Number
Battery	4	Y5043
Bracket	2	FA2815-B
Wafer	4	A2830-B
Wafer	2	A2831-A
Disc, Fiberglass	6	-----
Liner, Kraft Paper	2	-----
Nut, KEP, 6-32	12	-----
Screw, 6-32 x 3/8 PPN	4	-----
Screw, 6-32 x 3/8 SEMS	4	-----
Tube	2	FB2833-1-B
Screw, 6-32 x 1/2 PPN	4	-----

2.6.2 Procedure

2.6.2.1 There are two battery holders, one for the +22 volt supply and one for the -22 volt supply. Except for the polarity of the battery connections, the assembly procedure is the same for both. Refer to illustration, Figure 2-5.

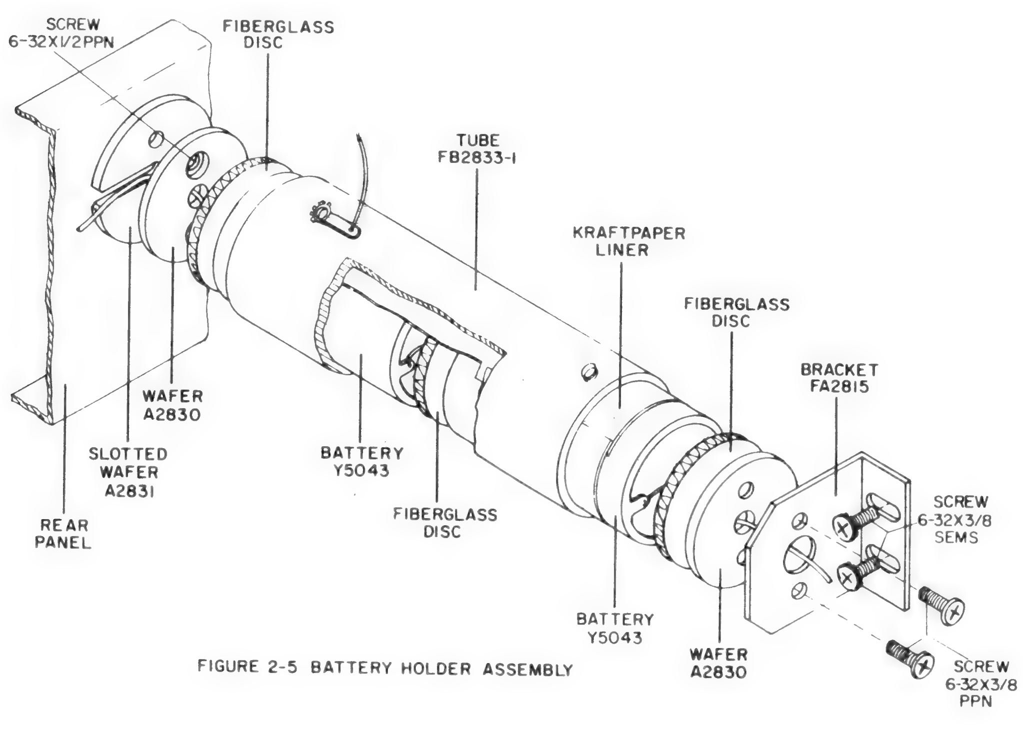


Figure 2-5. Installation of Battery Holders

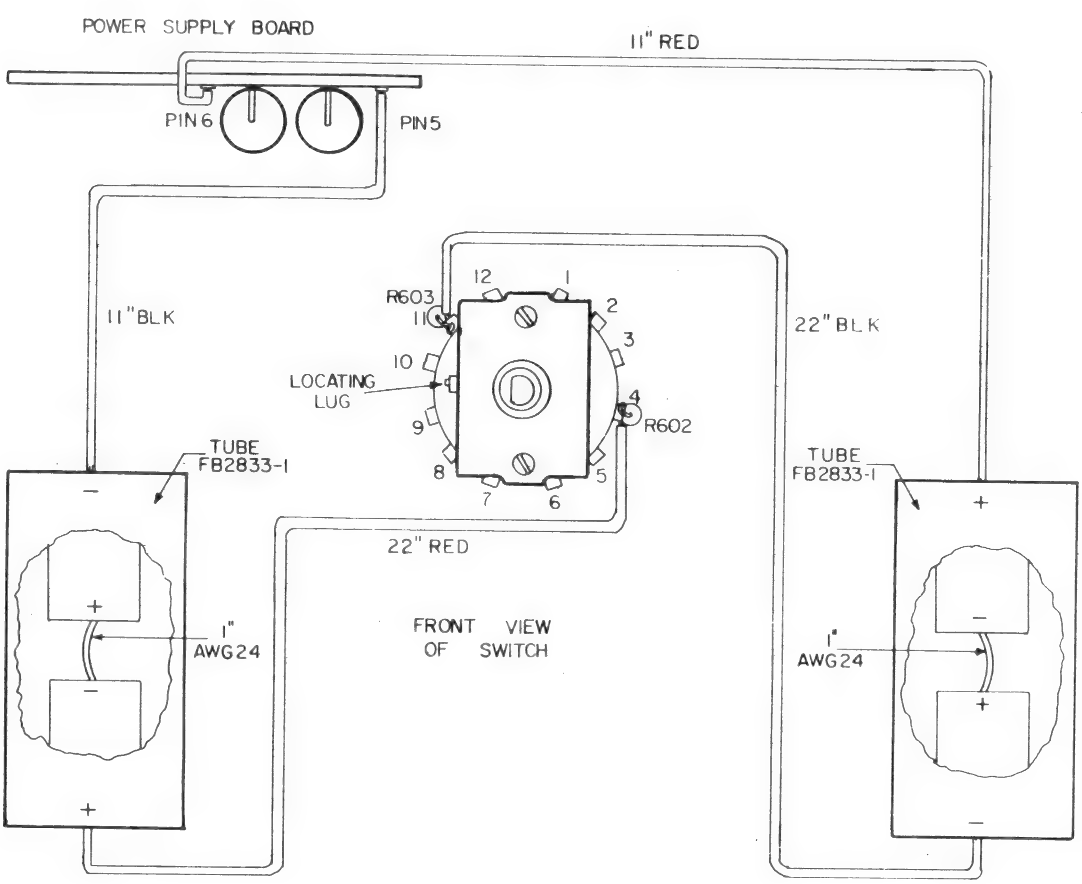
2.6.2.2 First connect 2 batteries in series (+ to -) with a 1-inch length of AWG24 stranded hookup wire. Then solder a 13-inch length of red-insulated wire to the remaining positive terminal, and a 11-inch length of black-insulated wire to the remaining negative terminal. Repeat for the other 2 batteries.

2.6.2.3 Assemble the battery holders in the order shown in the illustration, starting at the inside of the rear panel. The negative lead of the left hand batteries and the positive lead of the right hand batteries should be toward the rear panel. Thread wire through the fiberglass disc, through the center holes in the A2830-B wafer, and through the slot in the slotted wafer. Place a fiberglass disc between batteries. The battery lead toward the front should be threaded around the fiberglass disc, and through the center holes in the wafer and bracket. After the batteries are in place, trim the wires.

2.6.2.4 Connect the positive lead of the left hand battery assembly to the front end of R602 on the power switch, and connect the negative lead to terminal 5 on the power supply board.

2.6.2.5 Connect the negative lead of the right hand battery to the front end of R603 on the power switch, and connect the positive lead to terminal 6 on the power supply board.

2.6.2.6 Before using the filter with batteries alone, charge the batteries for 4 hours with the POWER switch in the LINE OPR BAT CHG position.



SECTION 3
INCOMING ACCEPTANCE AND INSPECTION

3.1 INTRODUCTION

The following procedure should be used to verify the filter operation within specifications for incoming inspection and periodic specification checks. Tests must be made with all covers in place. If the instrument is not operating within specifications refer to Section 5 and 6 before attempting any detailed maintenance. Before testing, follow the initial setup and operating procedures given in Section 2.

3.2 TEST EQUIPMENT REQUIRED

The following test equipment is required to perform these tests:

a. High impedance d-c voltmeter capable of measurements from 1 millivolt to 20 volts, Digitec Model 211 or equal.

b. A-C voltmeter capable of measurements from 100 microvolts to 10 volts rms. Ballantine Model 314, or equal.

c. Oscilloscope DC to 5 MHz, 10 mv/cm sensitivity.

d. Oscillator: 0.2 Hz to 1 MHz; with frequency accuracy better than 3%; distortion, hum noise, less than 0.05%; frequency response ±.05 dB (Krohn-Hite Model 4100A or equal).

e. Variable autotransformer for adjusting line voltage.

3.3 TEST PROCEDURE AND CONDITIONS

Table 3-1 gives the conditions and setup for testing the various filter characteristics. Unless otherwise specified in the table, the RESPONSE switch is in the MAX FLAT position, and the output load is greater than 1000 ohms. In the table, voltages are rms unless otherwise specified. To check operation of units equipped with batteries, conduct any of the performance tests in table 3-1 with the POWER switch in the BAT OPR position. If dc level cannot be zeroed with the unit in battery operation, or if unit does not provide full signal voltage, charge the batteries for 16 hours and recheck.

NOTE

Because the accuracy of a-c voltmeters is greatly reduced at frequencies below 10 Hz, it is necessary to use an oscilloscope in making some of the measurements required by this test procedure. It is recommended that the oscilloscope be set up to show 1 volt p-p as 20 divisions on the graticule. The -3 dB points (given as 0.63 to 0.77 vrms in the text) then become 12 to 16 divisions peak to peak.

Table 3-1. Acceptance Check out Procedure

Test	Function	HP	LP	Input Freq.	Voltage At Testpoint
1. Low Pass Operation	LP	-	200 x 100	10 kHz	1 volt at output
	Measure input voltage. Limits are .9 to 1.1 volts. Change osc. to 20 kHz. Output should read .6 to .8 volt. Switch LP to 200 x 10 and osc. to 2 kHz. Switch LP to 200 x 1 and osc. to 200 Hz. Switch LP to 200 x .1 and osc. to 20 Hz. Switch LP to 200 x .01 and osc. to 2 Hz. Switch LP to 200 x .001 and osc. to 0.2 Hz. With 1 volt output reference, output should read .63 to .77 volt at all cutoff settings.				
2. High Pass Operation	HP	200 x .001	-	10 Hz	1 volt at output
	Measure input voltage. Limits are .9 to 1.1 volt. Change osc. to 0.2 Hz. Output should read .63 to .77 volt. Change HP to 200 x .01 and osc. to 2 Hz. Change HP to 200 x .1 and osc. to 20 Hz. Change HP to 200 x 1 and osc. to 200 Hz. Change HP to 200 x 10 and osc. to 2 kHz. With 1 volt output reference output should read .63 to .77 volt at all cutoff settings. Change HP to 200 x 100 and osc. to 20 kHz. Output should read .6 to .8 volt.				
3. Band Pass Attenuation Slope 3a)	BP	20 x 1	200 x 10	1 kHz	1 volt at output
	Change the osc. to 20 Hz. Output should be .63 to .77 volt. Change osc. to 10 Hz and HP SLOPE switch to 6 dB/octave. Output should read .35 to .55 volt. Change SLOPE switch to 12 dB/octave. Output should read .15 to .4 volt. Change SLOPE switch to 18 dB/octave. Output should read .06 to .25 volt. Change SLOPE switch to 24 dB/octave. Output should read between 45 and 85 millivolts.				
3b)	Change the osc. to 2 kHz. Output should read .63 to .77 volt. Change osc. to 4 kHz and LP SLOPE switch to 6 dB/octave. Output should read .35 to .55 volt. Change SLOPE switch to 12 dB/octave. Output should read .15 to .4 volt. Change SLOPE switch to 18 dB/octave. Output should be .06 to .25 volt. Change SLOPE switch to 24 dB/octave. Output should read 45 to 85 millivolts.				

Table 3-1 (contd.) Acceptance Check out Procedure

Test	Function	HP	LP	Input Freq.	Voltage At Testpoint
4. 20 dB gain	BP	20 x 1	200 x 10	1 kHz	0.1 volt at input
	Switch GAIN switch to 20 dB. Output should read 0.9 to 1.1 volt. Set GAIN switch to 0 dB.				
5. Band Reject Operation	BR	200 x 10	20 x 1	10 Hz	1 volt at output
	Switch osc. to 20 Hz. Output should read .63 to .77 volt. Switch osc. to 200 Hz. Output should be less than 1 millivolt. Switch osc. to 2 kHz. Output should be .63 to .77 volt. Change osc. to 4 kHz. Output should be .9 to 1.1 volts.				
6. Maximum Signal Voltage	BP	60 x .1	60 x 100	600 Hz	1 volt at input
	Connect oscilloscope to output. Increase osc. amplitude to a point just below clipping on the output. Input voltage should be greater than 11 volts. Return osc. amplitude to zero, and switch GAIN to 20 dB. Increase osc. amplitude to a point just below clipping on the output. Input voltage should be greater than 1.1 volt.				
7. Impedance	BP	20 x 1	200 x 100	2 kHz	0.1 volt at output
	Shunt output with 50 ohm resistor. Voltage at output should drop to 0.05 ± .01 volt.				
8. Hum and Noise	BP	20 x 1	200 x 100	--	
	Short input. Output voltage should be less than 500 microvolts.				

SECTION 4
CIRCUIT DESCRIPTION

4.1 GENERAL

The Krohn-Hite Model 3750 Filter consists of an Input Amplifier, a Low Pass Section, a High Pass Section, an Output Amplifier, and a Power Supply. The switching of the various filter functions is shown in figure 4-1. In the Low Pass (LP) mode, the signal is applied to the Input Amplifier, through the Low Pass Section to the Output Amplifier. In the High Pass (HP) mode, the signal is applied to the Input Amplifier, through the High Pass Section to the Output Amplifier. In the Band Pass (BP) mode, the LP and HP sections are connected in series. In the Band Reject (BR) mode, the LP and HP sections are connected in parallel, and their outputs are added at the input to the Output Amplifier.

The GAIN switch operates on the input amplifier only, by controlling a 10:1 attenuator in the feedback loop.

The passband controls for the high - and low - pass sections tune the 4 - pole RC networks. Frequency ranges are determined by the capacitors, switched in decades by means of the multiplier controls on the front panel. The resistances are ganged potentiometers, and are continuously variable within a given range by means of the FREQ Hz dials.

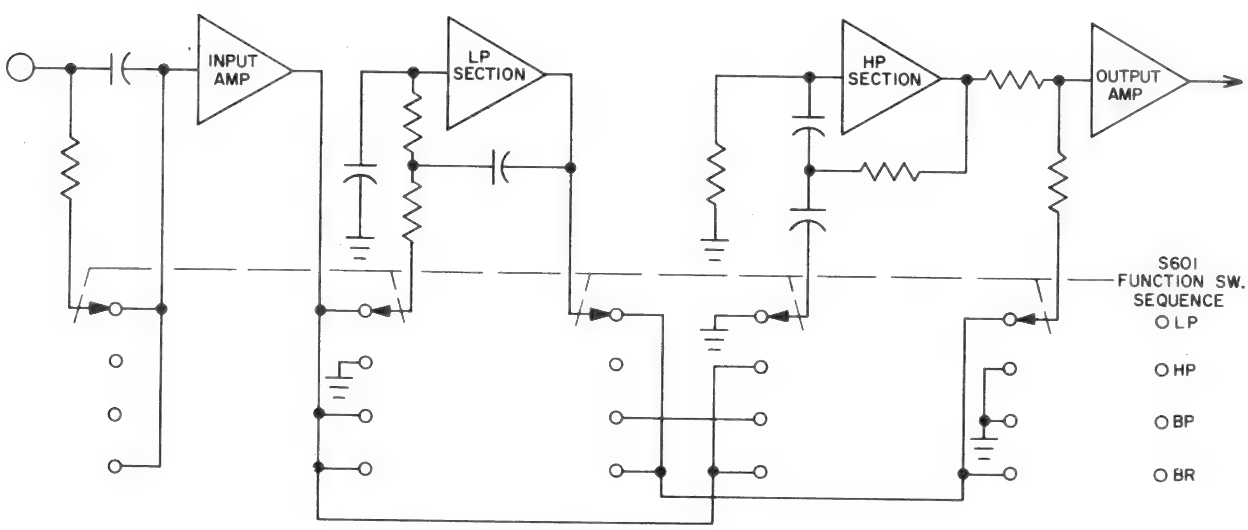


Figure 4-1. Model 3750 Function Selection Diagram

The SLOPE switches vary the attenuation slope of each section by switching the potentiometers and their associated capacitors into or out of the coupling and feedback networks. Figure 4-2 illustrates this action. The networks designated A, B, C, etc. are the cutoff frequency controls. For a slope of 6 dB per octave, networks F (Low Pass) and B (High Pass) are the only ones that are used in the RC circuits. (Notice, however, that the capacitor of network A is in series with the capacitor for network B in the 6 and 18 dB positions).

For an attenuation slope of 24 dB per octave, all four networks are used in each section. Table 4-1 shows which networks are used for each attenuation slope.

The RESPONSE switch is used to select a Butterworth (MAX FLAT) or an RC (LOW Q) response by changing the feedback characteristics of the LP and HP output stages.

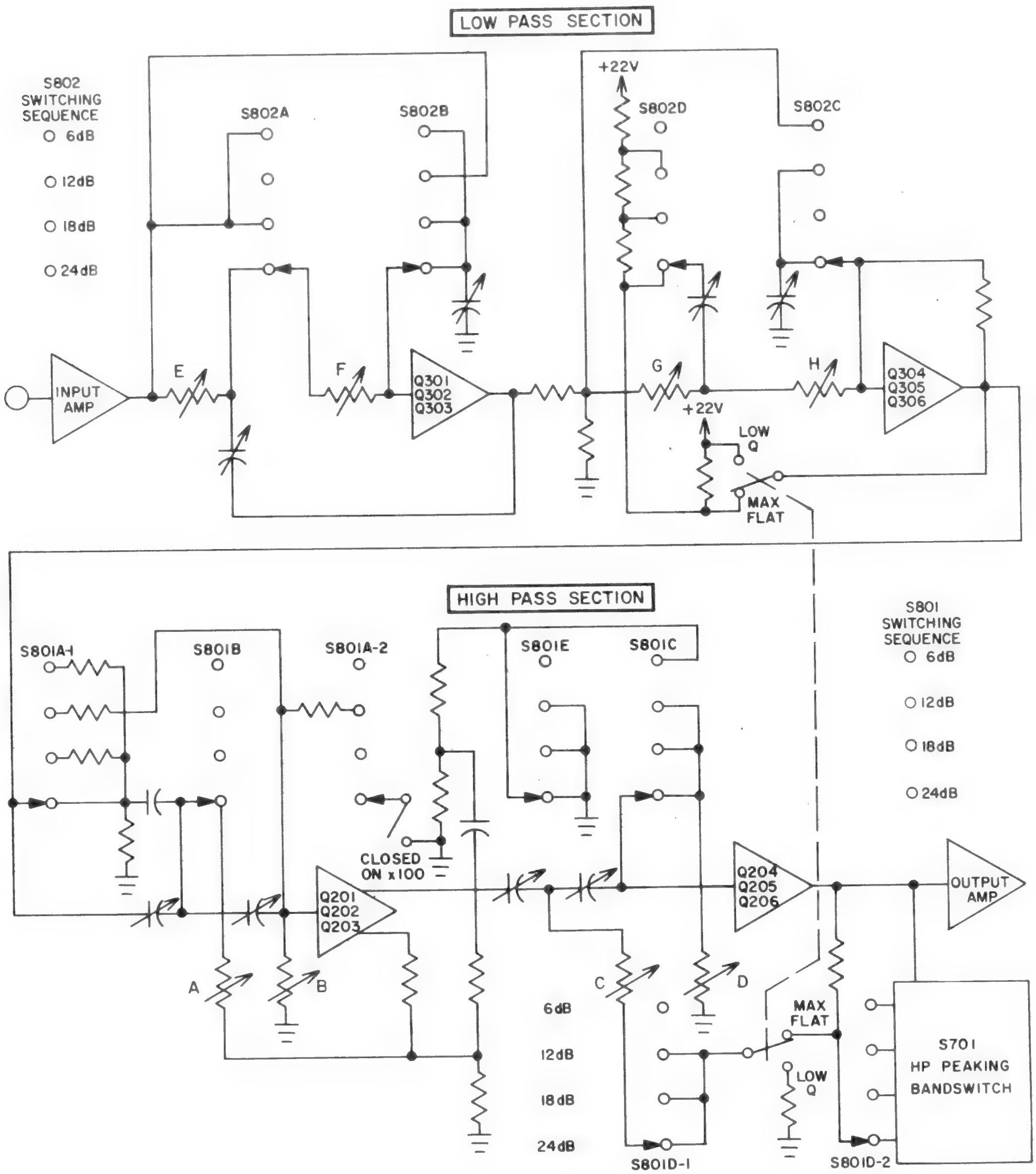


Figure 4-2. Model 3750 Slope Selection Diagram

Table 4-1. Attenuation Slope Selection

Attenuation Slope (dB/octave)	Network In Use (ref Figure 4-2)	
	High Pass	Low Pass
6	-- B -- --	-- F -- --
12	-- -- C D	-- -- G H
18	-- B C D	-- F G H
24	A B C D	E F G H

The various electronic circuits are described in detail in the following paragraphs.

4.2 INPUT AMPLIFIER

The input signal is resistance coupled to the input amplifier in the LP and BR modes, and capacitance-coupled in the HP and 3BP modes. The balanced output of O101 drives the bases of Q102 and Q103, which provide a low impedance signal for the RC networks. Broadbanding is accomplished by R102, R103, and C103 at the input, and R106, R107 and C105 in the feedback loop. R113 and C106 are used to prevent oscillation. The GAIN switch serves to shunt R115 with R110 (20 dB gain) or to ground R110 (0 dB gain), varying negative feedback in a 10-to-1 ratio.

4.3 LOW PASS SECTION

The low-pass section consists of two similar two-pole stages to form a quadratic amplifier. (The term quadratic is used here because the transfer function of the section is a quadratic equation). It can be seen from the schematic that while the two stages are similar in circuit arrangement, they differ in polarity; i. e., Q301, Q302, and Q303 are PNP, NPN, and PNP transistors respectively, while Q304, Q305, and Q306 are NPN, PNP, and NPN respectively. This arrangement has the effect of cancelling nonlinearities in transitor characteristics and compensating for drift due to temperature changes.

The input transistor of each stage is designed for very low current drain (R305 and R321 are 39 megohms) so as not to load the RC networks. RC networks are used in both stages for negative feedback and loop stabilization. The RESPONSE switch in combination with the slope switch, provides for selection of RC or Butterworth response by modifying feedback.

4.4 HIGH PASS SECTION

The high pass section consists of two stages; the first stage is single ended, and utilizes a buffer amplifier (Q202) in the feedback loop. On the two higher bands the gain of the loop is adjusted by means of P201. RC' s are used extensively in this stage to provide wide bandpass and compensate for stray capacitance.

The second stage (Q204, Q205, Q206) is similar to the input amplifier but the functions here are (a) to drive the peaking circuits for slope control, (b) to provide for selection of an RC or Butterworth response, and (c) to provide a low-impedance source for the following sections.

4.5 OUTPUT AMPLIFIER

The outputs of the low-pass and high-pass sections are added in the BR mode at the input of the output amplifier. Potentiometer P401 is used to equalize the HP and LP signals, which are applied to the base of Q401, and clamped at the same dc level as the output by the action of Q404. Q401 and Q402 are emitter-coupled and drive the constant current output stage, Q403 and Q404. Network R412-C404 provides negative feedback to the input. R410 and C403 are used to prevent oscillation and C403 is a bypass capacitor for resistor R406.

4.6 POWER SUPPLY

The power supply furnishes two regulated voltages of + 22 and -22 volts. The batteries, or rectifiers CR602 thru CR605 and filter capacitors C501 and C506, provide the unregulated dc voltages. Both supplies are of the typical series type. The + 22 volt supply is the master supply using Zener-connected Q504 as a reference and amplifiers Q502 and Q503 to drive the series regulator Q501. Short circuit protection is provided by the series resistor R502 which cuts off Q502 via diode CR501. The -22 volt supply is slaved to the + 22 volt supply. A divider network consisting of R524 and R525 sets the proper voltage level for amplifiers Q509 and Q506, which drive the series regulator Q505. Short circuit protection is provided by R514 and diode CR503. To insure starting, a Zener Z501 provides a negative voltage for the regulating amplifiers. Diode CR504 is normally conducting and permits Z501 to function when required. When power switch S602 is in the LINE OPR BAT CHG position, diodes CR601 and CR606 charge the batteries through current-limiting resistors R602 and R603.

SECTION 5
MAINTENANCE

5.1 INTRODUCTION

If the Model 3750 is not functioning properly and requires service, follow this procedure to locate the source of trouble. To obtain access to the interior of the filter, remove the screw centered at the rear of each cover; sliding off the side covers will unlock the top and bottom covers.

The general layout of major components, test points, screwdriver controls and adjustments is shown in Figure 5-1. A detailed component layout for the printed circuit card is included with the schematic diagram at the end of this book. Various check points and voltages are shown on the schematic diagram and are also marked on the printed circuit card.

First make a visual inspection; check the unit for such things as broken wires, burnt or loose components, or similar conditions which could cause trouble. Any troubleshooting of the filter will be greatly simplified if you understand the operation of the circuit. Before attempting detailed troubleshooting refer to Circuit Description Section 4.

5.2 POWER SUPPLY

The Power Supply consists of two separate regulated supplies of + 22 and -22 volts dc. The + 22 is used as a reference supply for the -22 and this fact should be kept in mind when doing any work on the supply, as a malfunction in the + 22 will be reflected in the -22. If the supplies do not seem to be working properly, the + 22 should be checked first. The two supplies have current limiting circuits which will shut down the supply if excessive current is being drawn from it. For this reason an apparent malfunction in the supply could be caused by an overload in one of the other circuits, e.g., a collector to emitter short in one of the output transistors will overload the power supply.

Nominal voltages for various points in the supplies are given in the schematic. If a malfunction occurs, the error signal thus developed should be traced through the circuit to find the faulty component. Let us suppose, for example, that the + 22 was lower than normal. This would produce an error signal which would make both the base and emitter of Q503 more negative than normal. Because the base moves less than the emitter, the total result is a lowering of the collector from its normal value. The base of Q502 should then be more negative than normal and the collector

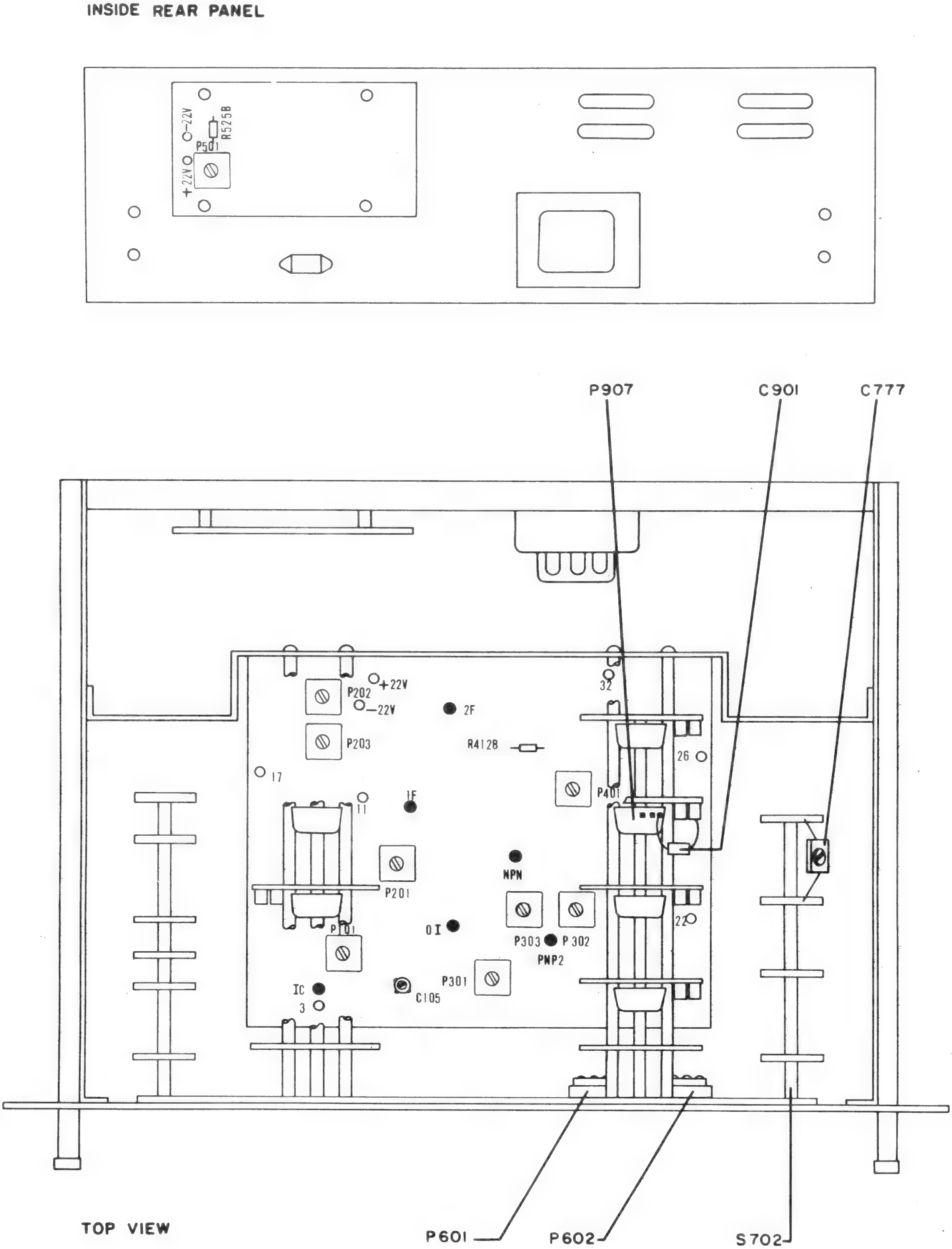


Figure 5-1. Trims and Adjustments

more positive. This will raise the base of series regulator transistor Q501 and finally should correct the output level. Had there been a defective component somewhere in the circuit, this correcting action would have been blocked. The same basic method of troubleshooting may also be used in the -22 volt supply.

If it becomes necessary to replace the reference zener Q504 the voltage of the +22 supply will have to be readjusted. This may be done by adjusting P501, so the supply is +22 ±1 volt. If the -22 supply exceeds -22 ±1 volt, change the fixed trim resistor R525B in parallel with R525A (do not disturb 525A).

5.3 SIGNAL TRACING ANALYSIS

If the power supplies appear to be correct but the Model 3750 is not working, the following signal tracing analysis should help locate the area of malfunction. Set the function switch to BP; set the RESPONSE switch to MAX FLAT position. Set both the low and high cutoff frequencies to 200 Hz Attenuation slope to 24 db per octave. Connect a 200 Hz 5-volt rms sine wave signal to the input terminals. If the test signal does not appear correctly at the output, the area of the malfunction may be localized by determining where in the Filter the signal first deviates from normal.

Table 5-1 shows various test points with their correct signal levels for band pass operation. If a test point is found whose signal level differs appreciably from the correct value, the circuitry immediately preceding that test point should be carefully checked.

Table 5-1. Test Point vs Signal Voltage

Function: Band Pass
Input: 200 Hz, 5 volts rms
HP and LP Settings: 200 x 1
Response: LOW Q
Gain: 0 dB
Slope: 24 dB/octave

Test Point	Voltage (rms)
3	5.0
OI	2.7
11	0.40
1F	0.47
17	0.22
2F	0.28
22	1.4
PNP	1.4
26	0.35
NPN	0.73
32	0.40

5.4 TUNING CIRCUITS

If signal tracing shows one of the tuning circuits to be faulty, it should be determined if the trouble is in the resistive or capacitive elements. If the trouble is in a capacitive element the malfunction will appear only on that position. If there is a problem in a resistive element, the trouble will be of a general nature and will show up on all multiplier bands.

The value of capacitance used on the highest band are selected to compensate for stray capacitance and are therefore, not completely in decade ratios of those used on the lower bands.

Each of the variable resistance elements consists of four potentiometers ganged together with a gear assembly. Each potentiometer has series and shunt trims to insure proper tracking. The trims and the angular orientation of the potentiometers are carefully adjusted at the factory. If it becomes necessary to change one of these potentiometers in the field, it should be replaced only with a unit supplied by the factory complete with proper trims. The angular orientation should then be carefully adjusted following the procedure supplied with the parts.

SECTION 6
CALIBRATION AND ADJUSTMENT

6.1 INTRODUCTION

Before making adjustments follow the procedure in Section 3 to determine if performance is within limits. The following procedure is provided for the adjustment and calibration of the filter in the field, and adherence to this procedure should restore the filter to its original specifications. If any difficulties are encountered, please refer to Maintenance, Section 5. If any question arises which is not covered by this procedure, please contact our factory service department. The locations of major components and trims are shown in Figure 5-1. The test points are marked on the PC board.

Access to the interior of the Model 3750 is gained by removing the screw centered at the rear of each cover; sliding off the side covers will unlock the top and bottom covers.

6.2 TEST EQUIPMENT REQUIRED

The following test equipment is required to perform these tests.

a. High impedance d-c voltmeter capable of measurements from 1 millivolt to 20 volts, Digitec Model 211 or equal.

b. A-C voltmeter capable of measurements from 100 microvolts to 10 volts rms, Ballantine Model 314A, or equal.

c. Oscilloscope DC to 5 MHz, 10 mv/cm sensitivity.

d. Oscillator; 0.01 Hz to 1 MHz; with frequency accuracy better than 3%; distortion, hum, and noise less than 0.05%; frequency response ±.05 dB (Krohn-Hite Model 4100A or equal).

e. Variable auto transformer for adjusting line voltage.

6.3 DC LEVEL ADJUSTMENTS

6.3.1 Positive Voltage

Connect the d-c voltmeter between ground and the +22V terminal at the left rear of the PC board. Limits are +21 to +22 volts. If out, adjust P501.

6.3.2 Negative Voltage

Connect the d-c voltmeter between ground and the -22V test point on the PC board. Limits are -21 to -22 volts. If out, trim R525. If trim is necessary, check and adjust the +22 volt level.

6.3.3 Amplifier Output

Short the filter input, set the FUNCTION switch to LP and the GAIN switch to 20 dB. Measure the d-c level at test point OI. Limits are -10 to +10 millivolts. If out, adjust P101.

6.3.4 HP Mode Output Level

With input shorted, set FUNCTION switch to HP. Measure level at filter output. Limits are 0 to ±10 millivolts. If out, adjust P601 (pot A on front panel).

6.3.5 Slope vs Output Level

6.3.5.1 With the input shorted, set FUNCTION switch to LP and LP dial to 200 x 100. Set LP SLOPE to 6 dB. Output level should be 0 to ±10 millivolts. If out adjust P602 (pot B on front panel).

6.3.5.2 Set LP dial to 20 x 100. Switch LP slope from 6 to 18 dB/octave. Adjust P303 for same level at 18 dB as at 6 dB.

6.3.5.3 Switch LP slope to 12 dB, and then to 24 dB/octave. Adjust P301 for same level at 24 dB as at 12 dB.

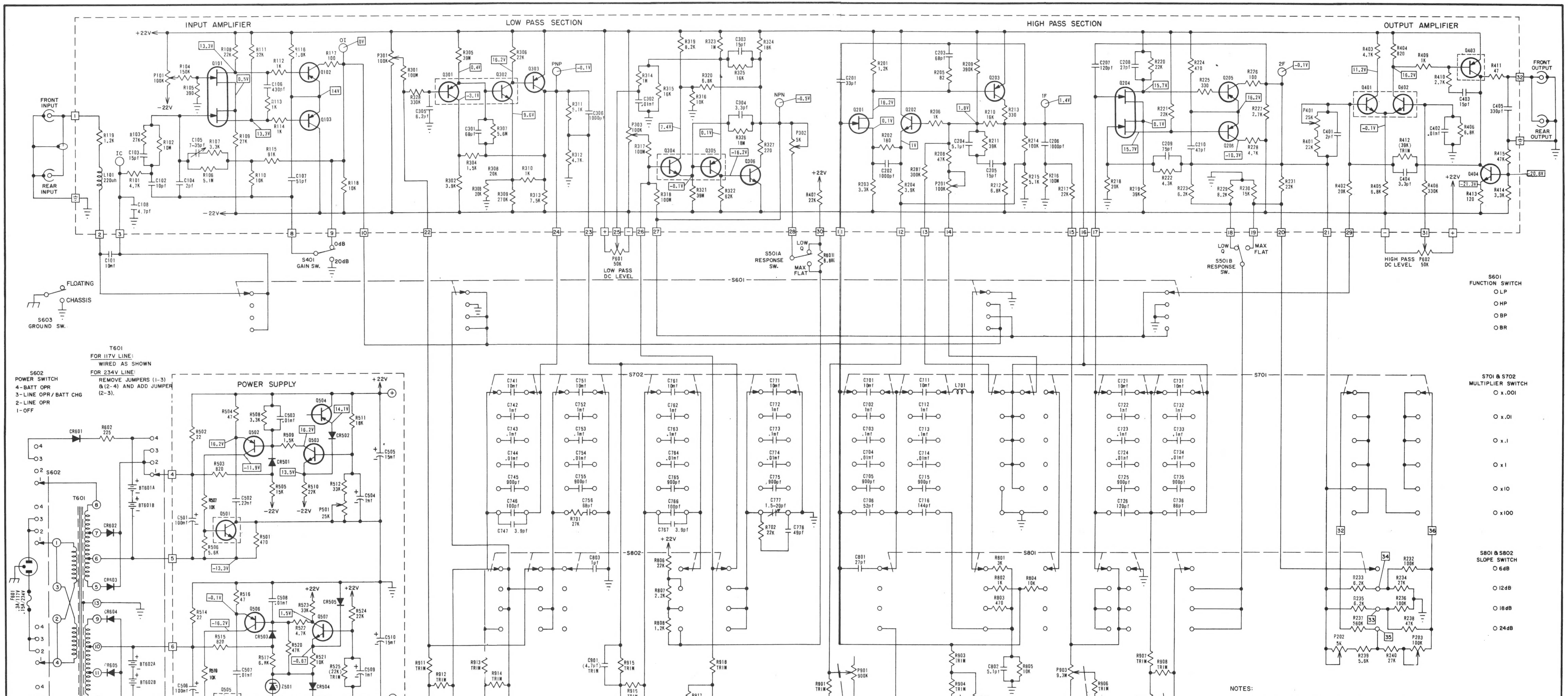
6.3.5.4 Repeat 6.3.5.1---pot B on front panel.

6.3.6 Calibration Procedure

The calibration procedure, which should be conducted only after the d-c levels have been set, is given in Table 6-1. In the table the initial setup is given in tabular form at the beginning of each test, and then follows a sequence of steps. It is important that the sequence be followed in order. Nominal oscillator output voltage at the beginning of all tests is 1 volt rms. Amplitude is then adjusted at the test point given. Unless otherwise specified, the GAIN switch is in the 0 dB position, the SLOPE switches are set for 24 dB/octave, the RESPONSE switch is on MAX FLAT, and the output load is greater than 1000 ohms.

Table 6-1. Calibration Procedure

Test	Function	HP Section	LP Section	Input Freq.	Voltage at Testpoint
1. LP vs HP Gain	LP	20 x 1	20 x 100	90 Hz	1 vrms at input
	Connect acvm to output. Switch FUNCTION from LP to HP. Output should change less than ±.02 vrms. If off adjust P401.				
2. Unity Gain	HP	20 x .001	--	90 Hz	1 vrms at input
	Connect acvm to output. Limits are 1 ± .1 vrms. If off trim R412.				
3. Frequency Response	HP	20 x .01	--	100 Hz	1 vrms at output
3a)	Switch osc. to 1 KHz, 10 KHz, and 100 KHz. Output voltage should change less than ±.03 vrms as switch is operated. Adjust C105 for minimum change.				
	HP	60 x 1	--	60 KHz	1 vrms at output
3b)	Switch HP to x 10 and x 100. Output should be .95 to 1.05 vrms. If off, adjust P201 while switch is in x 100 position.				
	HP	60 x .1	--	60 Hz	1 vrms at input
3c)	Connect acvm to output. Limits are .90 to 1.1 vrms. Switch HP to 60 x 1, and adjust HP dial to 0.7 vrms. Switch osc. to 600 Hz, and HP multiplier to X10. Output should be 0.63 to 0.77 vrms. Switch osc. to 6 KHz, and HP Multiplier to X100. Output should read 0.54 to 0.86 vrms. If off, adjust P203 with HP switch in X100 position.				
4. HP Dial Set	HP	60 x 1	--	60 Hz	1 vrms at input
	Connect oscilloscope vertical input to test point 2F, and horizontal input to test point 01. Adjust HP dial to close the ellipse. Dial should read 58 to 62. If off, loosen dial set screws and set to 60. Tighten set screws.				
5. HP Gain Calibration	HP	60 x .1	--	60 Hz	1 vrms at 2F
	Switch HP multiplier to X1. Voltage at test point 2F should be 0.7 ±0.07 vrms. If off, adjust P202.				
6. LP Dial Set	LP	20 x .001	60 x 1	60 Hz	1 vrms at output
	Oscilloscope horizontal input to test point 01, and vertical input to filter output. Adjust LP dial to close the ellipse. Dial should read 58 to 62. If off, loosen set screws and set dial to 60. Tighten set screws.				
7. LP Gain Calibration	LP	--	60 x 10	60 Hz	1 vrms at output
	Switch LP multiplier to X1. Output should be 0.7 ±0.07 vrms. If off, adjust P302.				
8. LP X 100 Calibration	LP	--	20 x 100	200 Hz	1 vrms at input
8a)	Switch osc. to 2 KHz. Output should be 0.7 ± 0.14 vrms. If off, adjust C777.				
8b)	Set LP to 200 x 100, and osc. for 2 KHz, 1 vrms at output. Switch osc. to 20 KHz. Output should be 0.7 ± 0.14 vrms. If off, adjust C901.				



NOTES:

1 – ALL RESISTORS IN OHMS UNLESS OTHERWISE SPECIFIED.

2 – VOLTAGES WERE MEASURED IN BAND PASS, WITH THE INPUT SHORTED; LP=20 x.1, HP=200 x100, SLOPE 24dB/oct, GAIN=0dB WITH SHELL OF OUTPUT BNC CONNECTOR AS GROUND. TOLERANCE ON VOLTAGES IS 20%.

3 – FLOATING GROUND

4 – CHASSIS GROUND

Model 3750(R)	SCHEMATIC	
DRN BY Cadieux	DATE DRN 11-1-70	
APPD BY E.H.K.	DATE REV. 4-10-74	
KROHN-HITE CORPORATION		APP.

RESISTORS

Symbol	Description			Mfr.	Part No.
R101	4.7K	10%	1/4W	AB	CB4721
R102	10M	10%	1/4W	AB	CB1061
R103	27K	10%	1/4W	AB	CB2731
R104	150K	10%	1/4W	AB	CB1541
R105	390	10%	1/4W	AB	CB3911
R106	5.1M	5%	1/4W	AB	CB5155
R107	3.3K	10%	1/4W	AB	CB3321
R108	22K	10%	1/4W	AB	CB2231
R109	27K	10%	1/4W	AB	CB2731
R110	10K	5%	1/4W	AB	CB1035
R111	22K	10%	1/4W	AB	CB2231
R112	1K	20%	1/4W	AB	CB1022
R113	1K	10%	1/4W	AB	CB1021
R114	1K	20%	1/4W	AB	CB1022
R115	91K	5%	1/4W	AB	CB9135
R116	1.8K	10%	1/4W	AB	CB1821
R117	100	20%	1/4W	AB	CB1012
R118	10K	10%	1/4W	AB	CB1031
R119	1.2K	10%	1/4W	AB	CB1221
R201	1.2K	10%	1/4W	AB	CB1221
R202	180	5%	1/4W	AB	CB1815
R203	3.3K	10%	1/2W	AB	EB3321
R204	3.9K	10%	1/4W	AB	CB3921
R205	82	10%	1/4W	AB	CB8201
R206	1K	20%	1/4W	AB	CB1022
R207	300K	5%	1/4W	AB	CB3045
R208	47K	10%	1/4W	AB	CB4731
R209	390K	10%	1/4W	AB	CB3941
R210	16K	5%	1/4W	AB	CB1635
R211	39K	10%	1/4W	AB	CB3931
R212	6.8K	10%	1/4W	AB	CB6821
R213	330	10%	1/4W	AB	CB3311
R214	100K	10%	1/4W	AB	CB1041
R215	5.1K	5%	1/4W	AB	CB5125
R216	100M	10%	1/4W	AB	CB1071
R217	22K	10%	1/4W	AB	CB2231
R218	20K	5%	1/4W	AB	CB2035
R219	39K	10%	1/4W	AB	CB3931
R220	22K	10%	1/4W	AB	CB2231
R221	22K	10%	1/4W	AB	CB2231
R222	4.3K	5%	1/4W	AB	CB4325
R223	6.2K	5%	1/4W	AB	CB6225
R224	470	10%	1/4W	AB	CB4711
R225	330	10%	1/4W	AB	CB3311
R226	100	20%	1/4W	AB	CB1012
R227	2.7K	10%	1/2W	AB	EB2721
R228	4.7K	10%	1/4W	AB	CB4721
R229	8.2K	10%	1/4W	AB	CB8221
R230	15K	10%	1/4W	AB	CB1531
R231	22K	10%	1/4W	AB	CB2231
R232	100K	10%	1/4W	AB	CB1041
R233	6.2K	5%	1/4W	AB	CB6825
R234	27K	10%	1/4W	AB	CB2731
R235	6.2K	5%	1/4W	AB	CB6825
R236	100K	10%	1/4W	AB	CB1041
R237	560K	10%	1/4W	AB	CB5641
R238	47K	10%	1/4W	AB	CB4731
R239	5.6K	10%	1/4W	AB	CB5621
R240	12K	10%	1/4W	AB	CB1231
R301	100M	10%	1/4W	AB	CB1071
R302	3.9K	10%	1/4W	AB	CB3921
R304	1.5K	10%	1/4W	AB	CB1521
R305	39M	10%	1/4W	AB	CB3961
R306	22K	10%	1/4W	AB	CB2231
R307	5.6M	10%	1/4W	AB	CB5651
R308	20K	5%	1/4W	AB	CB2035
R309	270K	10%	1/4W	AB	CB2741
R310	1K	10%	1/4W	AB	CB1021
R311	5.1K	5%	1/4W	AB	CB5125
R312	4.7K	10%	1/4W	AB	CB4721
R313	7.5K	5%	1/4W	AB	CB7525
R314	1M	10%	1/4W	AB	CB1051
R315	16K	5%	1/4W	AB	CB1635
R316	10K	10%	1/4W	AB	CB1031
R317	100M	10%	1/4W	AB	CB1071
R318	100M	10%	1/4W	AB	CB1071
R319	8.2K	10%	1/4W	AB	CB8221

Symbol	Description			Mfr.	Part No.
R320	6.8K	10%	1/4W	AB	CB6821
R321	39M	10%	1/4W	AB	CB3961
R322	62K	5%	1/4W	AB	CB6235
R323	1M	10%	1/4W	AB	CB1051
R324	18K	10%	1/4W	AB	CB1831
R325	16K	5%	1/4W	AB	CB1635
R326	18M	10%	1/4W	AB	CB1861
R327	220	10%	1/4W	AB	CB2211
R328	330K	10%	1/4W	AB	CB3341
R401	22K	10%	1/4W	AB	CB2231
R402	20K	5%	1/4W	AB	CB2035
R403	4.7K	10%	1/4W	AB	CB4721
R404	820	10%	1/4W	AB	CB8211
R405	6.8K	10%	1/4W	AB	CB6821
R406	6.8K	10%	1/4W	AB	CB6821
R407	22K	10%	1/4W	AB	CB2231
R408	330K	10%	1/4W	AB	CB3341
R409	1K	20%	1/4W	AB	CB1022
R410	2.7K	10%	1/4W	AB	CB2721
R411	47	10%	1/4W	AB	CB4701
R412	39K	10%	1/4W	AB	CB3931
R413	120	10%	1/4W	AB	CB1211
R414	3.3K	10%	1/4W	AB	CB3321
R415	47K	10%	1/4W	AB	CB4731
R501	470	10%	1W	AB	GB4711
R502	22	5%	1/2W	AB	EB2201
R503	820	10%	1/4W	AB	CB8211
R504	47	10%	1/4W	AB	CB4701
R505	15K	10%	1/4W	AB	CB1531
R506	5.6K	10%	1/4W	AB	CB5621
R507	10K	10%	1/4W	AB	CB1031
R508	3.3K	10%	1/4W	AB	CB3321
R509	1.5K	10%	1/4W	AB	CB1521
R510	22K	10%	1/4W	AB	CB2231
R511	18K	10%	1/4W	AB	CB1831
R512	33K	10%	1/4W	AB	CB3331
R513	560	10%	1W	AB	GB5611
R514	22	5%	1/2W	AB	EB2201
R515	820	10%	1/4W	AB	CB8211
R516	47	10%	1/4W	AB	CB4701
R517	6.8K	10%	1/4W	AB	CB6821
R518	5.6K	10%	1/4W	AB	CB5621
R519	10K	10%	1/4W	AB	CB1031
R520	47K	10%	1/4W	AB	CB4731
R521	10K	10%	1/4W	AB	CB1031
R522	4.7K	10%	1/4W	AB	CB4721
R523	33K	10%	1/4W	AB	CB3331
R524	22K	10%	1/4W	AB	CB2231
R525	22K	10%	1/4W	AB	CB2231
R601	5.8K	10%	1/4W	AB	CB6821
R602	225	5%	5W	TL	EL3
R603	225	5%	5W	TL	EL3
R701	27K	10%	1/4W	AB	CB2731
R702	22K	10%	1/4W	AB	CB2231
R801	3K	5%	1/4W	AB	CB3025
R802	1K	10%	1/4W	AB	CB1021
R803	470	10%	1/4W	AB	CB4711
R804	10K	10%	1/4W	AB	CB1031
R805	10K	10%	1/4W	AB	CB1031
R806	22K	5%	1/4W	AB	CB2235
R807	2.2K	5%	1/4W	AB	CB2225
R808	1.2K	10%	1/4W	AB	CB1221
R901	TRIM	10%	1/4W	AB	TYPE CB
R902	TRIM	10%	1/4W	AB	TYPE CB
R903	TRIM	10%	1/4W	AB	TYPE CB
R904	TRIM	10%	1/4W	AB	TYPE CB
R905	TRIM	10%	1/4W	AB	TYPE CB
R906	TRIM	10%	1/4W	AB	TYPE CB
R907	TRIM	10%	1/4W	AB	TYPE CB
R908	TRIM	10%	1/4W	AB	TYPE CB
R911	TRIM	10%	1/4W	AB	TYPE CB
R912	TRIM	10%	1/4W	AB	TYPE CB
R913	TRIM	10%	1/4W	AB	TYPE CB
R914	TRIM	10%	1/4W	AB	TYPE CB
R915	TRIM	10%	1/4W	AB	TYPE CB
R916	TRIM	10%	1/4W	AB	TYPE CB
R917	TRIM	10%	1/4W	AB	TYPE CB
R918	TRIM	10%	1/4W	AB	TYPE CB

CAPACITORS

Symbol	Description			Mfr.	Part No.
C101	10mf	10%	100V	TRW	X663F-17
C102	10pf	10%	500V	ASP	9213-10110
C103	15pf	10%	500V	ASP	9300-15110
C104	2pf	10%	500V	ASP	9206-10910
C105	7-35pf	TRIMMER		STT	7S-TRIKO-02-7-35-N1500
C106	430pf	10%	500V	ELM	DM19C431K
C107	51pf	10%	500V	ELM	DM15C510K
C108	4.7pf	10%	500V	ASP	9210-47910

Symbol	Description			Mfr.	Part No.
C201	33pf	5%	500V	ELM	DM15C330J
C202	1000pf	20%	500V	SP	C023B501E102M
C203	68pf	5%	500V	ELM	DM15C680J
C204	5.1pf	10%	500V	ASP	9210-51910
C205	15pf	10%	500V	ASP	9300-15110
C206	1000pf	20%	500V	SP	C023B501E102M
C207	120pf	5%	500V	ELM	DM15C121J
C208	27pf	10%	500V	ELM	DM15C270K
C209	75pf	10%	500V	ELM	DM15C750K
C210	47pf	10%	500V	ELM	DM15C470K

Symbol
C301
C302
C303
C304
C305
C306
C401
C402
C403
C404
C405
C501
C502
C503
C504
C505
C506
C507
C508
C509
C510
C701
C702
C703
C704
C705
C706
C711
C712
C713
C714
C715
C716
C721
C722
C723
C724
C725
C726

Symbol
Q101
Q102
Q103
Q201
Q202
Q203
Q204
Q205
Q206
Q301
Q302
Q303
Q304
Q305
Q306
Q401
Q402
Q403
Q404
Q501
Q502
Q503
Q504
Q505
Q506
Q507
CR501
CR502
CR503
CR504
CR505
CR601
CR602
CR603
CR604
CR605
CR606
Z501

AB	(01
AME	(15
ASP	(82
BKM	(30
BUS	(71
CI	(06
CW	(79
DLV	(99
ELM	(72
ERT	(72
GE	(03

CAPACITORS (CONT'D.)

Symbol	Description			Mfr.	Part No.
C301	68pf	5%	500V	ELM	DM15C680J
C302	.01mf	20%	500V	SP	C023B501G103M
C303	15pf	10%	500V	ASP	9300-15110
C304	3.3pf	10%	500V	ASP	9210-33910
C305	6.2pf	10%	500V	ASP	9212-62910
C306	1000pf	1%	500V	ELM	CM19C102F
C401	2pf	10%	500V	ASP	9208-20910
C402	.01mf	20%	500V	SP	C023B501G103M
C403	15pf	10%	500V	ASP	9300-15110
C404	3.3pf	10%	500V	ASP	9209-33910
C405	330pf	5%	500V	ELM	DM19C331J
C501	100mf	LYTIC	50V	SP	39D107G050EJ4
C502	.22mf	20%	50V	ERT	8131-100-651-224M
C503	.01mf	20%	500V	SP	C023B501G103M
C504	1mf	20%	35V	SP	196DI05X0035HA2
C505	15mf	LYTIC	50V	SP	TT150U050BONIP
C506	100mf	LYTIC	50V	SP	39D107G050EJ4
C507	.01mf	20%	500V	SP	C023B501G103M
C508	.01mf	20%	500V	SP	C023B501G103M
C509	1mf	20%	35V	SP	196DI05X0035HA2
C510	15mf	LYTIC	50V	SP	TT150U050BONIP
C701	10mf	+1/2%-3 1/2%	50V	TRW	X663F-2
C702	1mf	+1/2%-3 1/2%	200V	TRW	X663F-9
C703	.1mf	+1%-3%	200V	TRW	X663F-5
C704	.01mf	+1%-3%	200V	TRW	X663F-1
C705	900pf	1%	500V	ELM	CM19C901F
C706	52pf	5%	500V	ELM	CM15C520J
C711	10mf	+1/2%-3 1/2%	50V	TRW	X663F-2
C712	1mf	+1/2%-3 1/2%	200V	TRW	X663F-9
C713	.1mf	+1%-3%	200V	TRW	X663F-5
C714	.01mf	+1%-3%	200V	TRW	X663F-1
C715	900pf	1%	500V	ELM	CM19C901F
C716	144pf	5%	500V	ELM	CM15C1440J
C721	10mf	+1/2%-3 1/2%	50V	TRW	X663F-2
C722	1mf	+1/2%-3 1/2%	200V	TRW	X663F-9
C723	.1mf	+1%-3%	200V	TRW	X663F-5
C724	.01mf	+1%-3%	200V	TRW	X663F-1
C725	900pf	1%	500V	ELM	CM19C901F
C726	120pf	5%	500V	ELM	CM15C121J

Symbol	Description			Mfr.	Part No.
C731	10mf	+1/2%-3 1/2%	50V	TRW	X663F-2
C732	1mf	+1/2%-3 1/2%	200V	TRW	X663F-9
C733	.1mf	+1%-3%	200V	TRW	X663F-5
C734	.01mf	+1%-3%	200V	TRW	X663F-1
C735	900pf	1%	500V	ELM	CM19C901F
C736	86pf	5%	500V	ELM	CM15C860J
C741	10mf	+1/2%-3 1/2%	50V	TRW	X663F-2
C742	1mf	+1/2%-3 1/2%	200V	TRW	X663F-9
C743	.1mf	+1%-3%	200V	TRW	X663F-5
C744	.01mf	+1%-3%	200V	TRW	X663F-1
C745	900pf	1%	500V	ELM	CM19C901F
C746	100pf	1%	500V	ELM	CM19C1040F
C747	3.9pf	10%	500V	ASP	9209-39910
C751	10mf	+1/2%-3 1/2%	50V	TRW	X663F-2
C752	1mf	+1/2%-3 1/2%	200V	TRW	X663F-9
C753	.1mf	+1%-3%	200V	TRW	X663F-5
C754	.01mf	+1%-3%	200V	TRW	X663F-1
C755	900pf	1%	500V	ELM	CM19C901F
C756	68pf	5%	500V	ELM	CM15C680J
C761	10mf	+1/2%-3 1/2%	50V	TRW	X663F-2
C762	1mf	+1/2%-3 1/2%	200V	TRW	X663F-9
C763	.1mf	+1%-3%	200V	TRW	X663F-5
C764	.01mf	+1%-3%	200V	TRW	X663F-1
C765	900pf	1%	500V	ELM	CM19C901F
C766	100pf	1%	500V	ELM	CM19C1040F
C767	3.9pf	10%	500V	ASP	9209-39910
C771	10mf	+1/2%-3 1/2%	50V	TRW	X663F-2
C772	1mf	+1/2%-3 1/2%	200V	TRW	X663F-9
C773	.1mf	+1%-3%	200V	TRW	X663F-5
C774	.01mf	+1%-3%	200V	TRW	X663F-1
C775	900pf	1%	500V	ELM	CM19C901F
C776	49pf	5%	500V	ELM	CM15C490J
C777	1.5-20pf	TRIMMER		ELM	T50210
C801	27pf	10%	500V	ELM	DM15C270K
C802	5.1pf	10%	500V	ASP	9210-51910
C803	1pf	10%	500V	ASP	9206-10910
C901	TRIM	5%	500V	ELM	TYPE DM

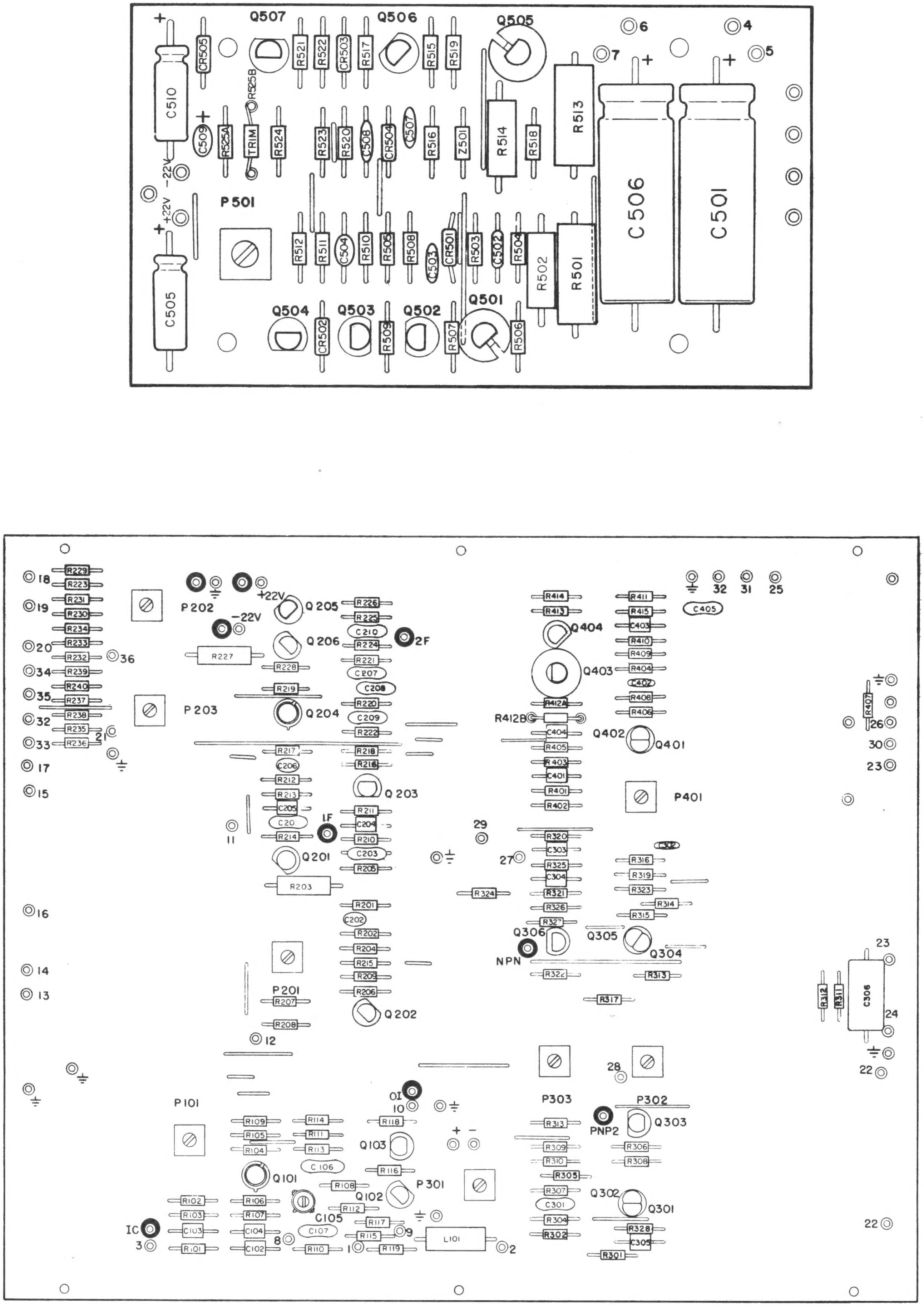
TRANSISTORS, DIODES & MISC.

Symbol	Description			Mfr.	Part No.
Q101	SU2365			SIL	SU2365
Q102	MPS6518			MOT	MPS6518
Q103	MPS6518			MOT	MPS6518
Q201	2N4302			AME	2N4302
Q202	TIS97			TI	TIS97
Q203	MPS6518			MOT	MPS6518
Q204	SU2365			SIL	SU2365
Q205	MPS6518			MOT	MPS6518
Q206	MPS6518			MOT	MPS6518
Q301	2N5087			GE	2N5087
Q302	TIS97			TI	TIS97
Q303	2N5087			GE	2N5087
Q304	TIS97			TI	TIS97
Q305	2N5087			GE	2N5087
Q306	TIS97			TI	TIS97
Q401	MPS6515			MOT	MPS6515
Q402	MPS6515			MOT	MPS6515
Q403	TIS93			TI	TIS93
Q404	TIS97			TI	TIS97
Q501	TIS92			TI	TIS92
Q502	MPS6518			MOT	MPS6518
Q503	MPS6515			MOT	MPS6515
Q504	MPS3640			MOT	MPS3640
Q505	TIS92			TI	TIS92
Q506	MPS6518			MOT	MPS6518
Q507	MPS6515			MOT	MPS6515
CR501	1N4149			TR	1N4149
CR502	1N4149			TR	1N4149
CR503	1N4149			TR	1N4149
CR504	1N4149			TR	1N4149
CR505	1N4149			TR	1N4149
CR601	1N4004			MSC	1N4004
CR602	1N4002			MSC	1N4002
CR603	1N4002			MSC	1N4002
CR604	1N4002			MSC	1N4002
CR605	1N4002			MSC	1N4002
CR606	1N4004			MSC	1N4004
Z501	1N971	5%	27V	CI	1N971

Symbol	Description			Mfr.	Part No.
P101	100K	10%	1/2W	BKM	72PM
P201	100K	10%	1/2W	BKM	72PM
P202	5K	10%	1/2W	BKM	72PM
P203	100K	10%	1/2W	BKM	72PM
P301	100K	10%	1/2W	BKM	72PM
P302	5K	10%	1/2W	BKM	72PM
P303	100K	10%	1/2W	BKM	72PM
P401	25K	10%	1/2W	BKM	72PM
P501	25K	10%	1/2W	BKM	72PM
P601	50K		3/4W	CTS	CD1371
P602	50K		3/4W	CTS	CD1371
P901	900K	20%	2W	AB	J95675
P902	2.5M	20%	2W	AB	J95676
P903	9.3M	30%	2W	AB	J95677
P904	250K	10%	2W	AB	J95728
P905	2.5M	20%	2W	AB	J95676
P906	2.5M	20%	2W	AB	J95676
P907	2.5M	30%	2W	AB	J95676
P908	900K	20%	2W	AB	J95675
S401	SLIDE SWITCH			CW	GF326
S501A	SLIDE SWITCH			CW	GF326
S501B	SLIDE SWITCH			CW	GF326
S601	ROTARY SWITCH			KH	B2791
S602	ROTARY SWITCH			KH	B2832
S603	SLIDE SWITCH			CW	G123
S701	ROTARY SWITCH			KH	B2792
S702	ROTARY SWITCH			KH	B2878
S801	ROTARY SWITCH			KH	C2879
S802	ROTARY SWITCH			KH	B2790
T601	POWER TRANSFORMER			KH	B2773
F601	.3A/117V SLO-BLO			BUS	MDL
	.15A/234V SLO-BLO			BUS	MDL
L101	220uhy	10%	.4W	DLV	3500-16
L701	FERRITE BEAD			STK	57-0181
BT601A	BATTERY			KH	Y5043
BT601B	BATTERY			KH	Y5043
BT602A	BATTERY			KH	Y5043
BT602B	BATTERY			KH	Y5043

MANUFACTURERS CODE

AB	(01121)	Allen Bradley Co.	Milwaukee, Wisc.
AME	(15815)	Amelco Inc.	Mt. View, Calif.
ASP	(82142)	Airco Speer	Dubois, Pa.
BKM	(30646)	Beckman Instr. Inc.	Cedar Grove, N.J.
BUS	(71400)	Bussman Mfg. Co.	St. Louis, Mo.
CI	(06751)	Components, Inc.	Biddeford, Maine
CW	(79727)	Continental Wirt Elec.	Philadelphia, Pa.
DLV	(99800)	Delevan Electronics	East Aurora, N.Y.
ELM	(72136)	Electromotive Mfg.	Willimantic, Conn.
ERT	(72982)	Erie Technological	Erie, Pa.
GE	(03508)	General Electric	Syracuse, N.Y.
KH	(88865)	Krohn-Hite Corp.	Cambridge, Ma.
MSC	(14552)	Micro Semiconductor Corp.	Culver City, Calif.
MOT	(04713)	Motorola Semiconductor	Phoenix, Ariz.
SIL	(17856)	Siliconix	Sunnyvale, Calif.
SP	(56289)	Sprague Electric Co.	North Adams, Ma.
STK	(78488)	Stackpole	St. Marys, Pa.
STT		Stettner-Trush	Cazanovia, N.Y.
TEL		Teledyne Corp.	Mountain View, Cal.
TI	(01295)	Texas Instruments, Inc.	Dallas, Texas
TL	(94322)	Tel Labs	Manchester, N.H.
TR	(03877)	Transitron Electric Co.	Wakefield, Ma.
TRW	(84411)	TRW Corp.	Ogallala, Neb.



PC BOARD LAYOUT